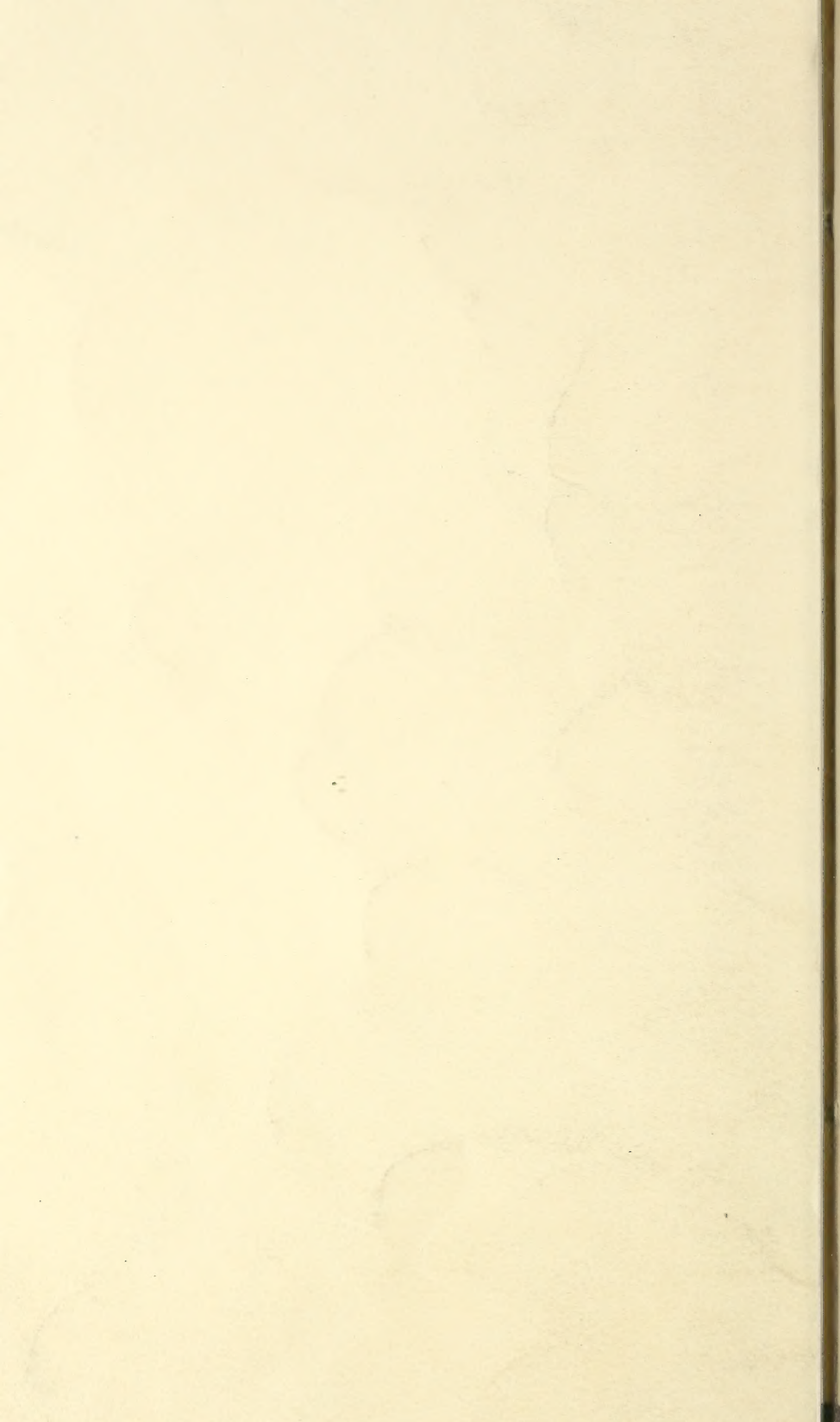
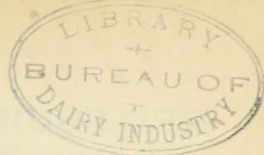


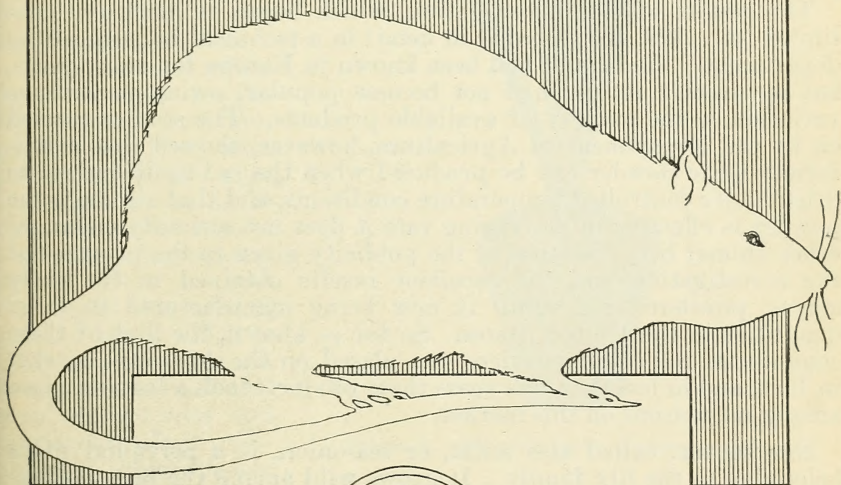
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RED-SQUILL POWDER in RAT CONTROL



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INCREASED use in this country of powdered red squill for killing rats, following its recommendation by the United States Department of Agriculture, has resulted in many inquiries concerning its properties, characteristics, and use, and particularly its effect upon other animals. This leaflet has been prepared to assist in making replies.

The principal rat poisons on the American market in 1923 were phosphorus, arsenic, barium carbonate, and strychnine. At that time the Department of Agriculture recommended barium carbonate as the most practical rat poison, because it is effective when properly used, inexpensive, and less dangerous to human beings than the other three. In spite of its relatively low toxicity, however, and the fact that its effects are readily counteracted by a simple antidote, domestic and other valuable animals were being killed and human life menaced through its widespread use. A raticide devoid of such dangers was needed, and inquiry by the department into many known poisons led to an exhaustive study of red squill (*Urginea maritima*).

The results of this investigation, which began in 1923 and continued into 1929, are recorded in detail in a technical bulletin of the department.¹ Red squill had been known in Europe for many years, but apparently its use had not become popular, owing to extreme variation in the toxicity of available products. The studies carried on by the Department of Agriculture, however, showed that a uniformly toxic powder can be produced when the red-squill bulbs are dried under controlled temperature conditions, and that although the powder is effective in destroying rats it does not seriously endanger other animal life. Because of the publicity given to the progress of the investigation and the excellent results obtained in the early stages, powdered red squill is now being manufactured in large quantities in the United States. So far as known, the first of these commercial red-squill powders was placed on the American market in 1926, and in less than five years these products took a leading place among rat poisons on this market.

RED SQUILL, called also scilla, or sea-onion, is a perennial plant belonging to the lily family. It grows wild among the hills bordering the Mediterranean, especially in southern Italy,

What Is Red Sicily, and in Sardinia, and along the Libyan coast.
Squill?

The onionlike bulbs occasionally attain a weight of 10 to 15 pounds, although those that find their way into commercial channels usually weigh from 1 to 8 pounds. They are gathered usually during the dormant period in summer and early in fall. The pointed, bladelike, deep-green leaves (fig. 1) dry up before the flower blooms in spring. The small flowers, which are

¹ Technical Bulletin No. 134. Red-Squill Powders as Raticides. For sale by the Superintendent of Documents, Government Printing Office, Washington, D. C., at 10 cents a copy.

white with green veins, are borne on a tall stem, and the fruit is a 3-celled capsule, with flat, winged seeds having a thick black shell. The plant, though ornamental, is rarely seen in flower gardens, and attempts to grow it on a commercial scale in this country have proved discouraging. It is reported, however, that squill is being successfully cultivated for the drug trade on a small scale in Italy and that the cultivated variety yields heavily, each plant producing on the average about 15 pounds of bulb after five or six years' growth.

There are two commercial varieties of squill, which apparently are not distinguishable botanically. White squill is the product official in various pharmacopœias, and is used in human medicine as a heart tonic, emetic, diuretic, and nauseant expectorant. Red squill has all the properties of white squill and in addition contains active toxic constituents, or glucosides, that have not been chemically isolated and identified.

Both red and white squill contain needle-like crystals (calcium-oxalate raphides) that, though essentially non-toxic, are irritating to the skin and cause a nettlelike, stinging sensation. They also give the squill its acrid, prickly taste, which is objectionable to human beings and to most animals, except rats and house mice. It is probably this objectionable taste that renders squill comparatively harmless, combined with its emetic effect—which causes most animals except rats and mice to vomit bait containing it.

RED-SQUILL POWDERS vary greatly in toxicity, although those prepared under conditions worked out during the course of the investigation were found to be fairly uniform in this respect. The average lethal dose of the most toxic powders produced was found to be approximately 1 grain per one-half pound of rat; that is, 1 grain of the powdered red squill would kill a rat weighing half a pound in less than three days. Powders prepared experimentally under varying con-



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FIGURE 1.—Red-squill plant (*Urginea maritima*)

ditions killed $\frac{1}{2}$ -pound rats, in doses varying from less than half a grain of squill to more than 35 grains. Sun-dried squill powders, which can be produced inexpensively, are considered unreliable, as they vary from a fairly high toxicity to practically none. White-squill powders have failed to kill in doses up to 70 grains and are therefore apparently nontoxic to rats.

THE DEPARTMENT'S investigations of numerous manufacturing processes have demonstrated that it is necessary to dry red squill under controlled temperature conditions in order to obtain a powder of maximum toxicity. The bulbs are sliced thin after the dry outer husks have been removed and then are placed in a previously heated drying oven and held at a constant heat of 80° C. (176° F.) until thoroughly dried. (Red squill dried at higher or lower temperatures has been found less toxic than when dried at approximately 80° C.) After being dried the squill should be ground fine enough to pass through a 40-mesh sieve, when it should be packed in air-tight containers, as otherwise moisture absorbed from the air will cause the powder to harden. Thoroughly dried, squill apparently does not deteriorate, and kept in an air-tight container it will retain its original toxicity indefinitely.

Powders made by this process should kill rats in doses of less than 3 grains of squill per pound of body weight. Because of the variability of different lots of red squill, manufacturers should carefully test the toxicity of every shipment. This may be done by feeding carefully weighed quantities of the powders to five or more white rats that have previously been starved for 18 hours. The rats should be weighed and placed in separate cages. The squill to be tested should be mixed thoroughly with fine meal in 10 per cent concentration and fed to the rats in quantities so computed as to give the rats doses of $1\frac{1}{2}$, 3, and 5 grains per pound of body weight in order to determine the approximate minimum lethal dose. The minimum lethal dose is the smallest dose that will kill within five days all rats fed.

This process is somewhat difficult unless the necessary equipment is available. When such equipment is lacking it is advisable to have the tests made by a commercial bioassayer. If all rats do not die from doses of 5 grains of squill per pound of body weight, the powder is too weak for an effective raticide. A very toxic powder should kill all rats at 3 grains per pound and at least 50 per cent with a dose of $1\frac{1}{2}$ grains per pound. Variation in the toxicity of different lots of squill powder can be overcome by mixing powders of higher toxicity with those of lower so long as the resulting compound will kill all rats when fed at the rate of 5 grains per pound of body weight. This has been suggested as a standard, but oven-dried squill powders now on the market are more toxic. Highly toxic powders may be mixed with food in the proportion of 1 ounce of squill to 1 pound of food, which will insure the rat getting a lethal dose even if it eats only a small quantity of the bait. (It is safe to figure that a rat will eat enough bait at one time to equal 1 per cent of its body weight.)

SINCE THE PUBLICATION of Farmers' Bulletin 1533, Rat Control, in 1927, in which the use of red squill was first recommended as a rat

Preparation of Baits poison by the department, large quantities of red-squill bait have been used. The Bureau of Biological Survey during the ensuing three years assisted in more than 150 cooperative county, city, and town campaigns, in which more than 40,000 pounds of squill bait were used. A careful check of results made in most of these campaigns indicated that a thorough clean-up of rats (fig. 2) was made on at least 75 per cent of the premises treated. This record furnishes ample proof of the acceptability and efficacy of red-squill powder as a raticide.

In using powdered red squill to destroy rats the choice of bait is most important. The goal is to destroy every rat at one application; otherwise survivors become suspicious and are hard to dispose of later. This requires an ample supply of baits that will appeal strongly to the appetites of the rats. Unfortunately, the tastes of rats, like those of human beings, vary, so that it is not possible to appeal to the palate of every rat with a single food. In order to obtain the best results several kinds of bait should be exposed at the same time, so that every rat will have a choice of foods. The following directions for preparing baits are the result of long experience of specialists in rat control:

Fish.—Fresh fish ground in a meat chopper is one of the most attractive baits for rats. If fresh fish is not available, a cheap grade of canned salmon, canned mackerel, or sardines in oil may be used. Mix 1 ounce of powdered red squill with a little water to form a thin paste free of lumps, add to 1 pound of fish, and mix thoroughly.

Meat.—Mix 1 ounce of powdered red squill with a little water to form a thin paste free of lumps, and add to 1 pound of fresh ground meat and mix thoroughly. Hamburg steak is most commonly used.

Cereals.—Mix together dry 1 ounce of powdered red squill and 1 pound of cereal meal, such as oatmeal, graham flour, corn meal, or bran. Add 1 pint of sweet milk or water and stir to a mushy consistency.

Fruits and vegetables.—Using a pepper shaker, dust powdered red squill over thin slices of fresh fruit or vegetables and stir or shake as the powder is applied to insure even distribution. A small muskmelon, for example, should be cut into about 16 slices and each slice cut into 3 sections. This will require 1 ounce of powdered squill and will make 48 baits. Three medium-sized tomatoes or three bananas, each cut into about 16 sections, may be similarly used for each ounce of squill powder.

SO FAR AS POSSIBLE all sources of food for rats should be removed before exposing squill baits. Garbage cans should be covered, food
Exposing Baits hoppers emptied, and all accessible food put into tight containers. The freshly prepared bait should be exposed late in the afternoon in order that it may be reasonably fresh when the rats commence feeding.

Every part of the premises where rats are likely to be present should be thoroughly treated, particularly those places in which rats have been accustomed to feed. A large number of small baits is more effective than a few large baits. Put out the bait in quarter-teaspoon pieces, or in quantities about the size of the average marble. Place

them consecutively, first a meat bait, then a fish bait, then a cereal bait, then meat, and so on. In poultry pens it is best to expose the baits in the feeding troughs while the chickens are shut up; or the baits may be exposed behind boxes or boards so leaned against the wall to form a runway for rats that the chickens can not reach them.

Baits should be left out for three days, after which all those uneaten should be collected and destroyed. If any sign of live rats is noted after one week, wait two additional weeks and then prebait for several nights before exposing more red-squill bait. Prebaiting is important if an unsuccessful effort has previously been made to destroy rats. This consists of exposing fresh untreated foods prepared in precisely the same way as the squill baits except that the squill is omitted. These clean baits should be put out at 2-day intervals, and all not consumed should be destroyed the morning following their exposure until the suspicion of the rats has been overcome and they take the baits freely. When this occurs, substitute the squill baits, and a complete clean-up should result.

RATS THAT have eaten a fatal dose of red squill usually become lethargic, or dopey, within an hour or two, and from 4 to 14 hours later they exhibit characteristic tremors and depression in the hind legs. This condition is followed by progressive paralysis of the trunk and forelegs, breathing becomes labored, and the animal starts to roll over and over in a peculiar and extremely characteristic manner. This rolling motion continues at intervals for half an hour, or possibly 24 hours, before death, depending upon the dose taken. Few rats that show these symptoms recover. Post-mortem examinations have indicated acute dilatation of the heart to be the probable cause of death from red squill, although continuation of the heart beat in many instances after breathing had stopped also indicated that respiratory paralysis plays a part. Irritation of the digestive tract also is pronounced, but not to an extent that would prove fatal.



FIGURE 2.—Although rats poisoned with red squill usually die underground, 238 were picked up on a Kansas farm after the baits were exposed

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IN ADDITION to its effectiveness in destroying rats, the principal characteristic of red squill that recommends it as a raticide is its relative harmlessness to human beings and domestic animals. In most cases cats, dogs, chickens, and other animals that were offered foods poisoned with red squill either refused or promptly vomited them.

Effect on Cats in particular disliked the baits and as they
Other Ani- would hardly touch food containing 1 per cent of red squill, whereas
mals 5 to 10 per cent is the usual concentration in rat baits, and it was concluded that cats probably would not eat them. Dogs also showed aversion for baits containing low concentrations of red squill, although in two instances they gulped down baits containing 10 per cent, but vomiting was the only effect noted.

Chickens have a relatively high resistance to red squill, and when fed a 10 per cent concentration in mash to the exclusion of all other foods for a period of two weeks, they showed no apparent ill effects. Baby chicks are not likely to eat enough feed containing 10 per cent of powdered red squill to cause death, even if no other feed is available. Dead rats should always be removed from poultry runs, however, as decomposed flesh or maggots, if eaten, may cause limberneck.

Pigeons also showed marked immunity, refusing to eat mash containing 10 per cent of squill powder, and when large doses were injected into the crop, vomiting was the only result.

Pigs refused to eat red-squill baits mixed in the proportion recommended for rat control and could not be starved into taking any of it, though when offered the same food (tankage) without the squill they ate it greedily. They showed a marked dislike for bait even in the weakest mixtures and could not be induced to eat it in a quantity that would produce ill effects. Pigs can be killed with red squill by forced feeding in the laboratory, but it is highly improbable that they will eat enough squill baits, mixed in the proportion (1:16) recommended for rat control to prove injurious.

In field tests, prairie dogs and pocket gophers refused to eat red-squill baits, but house mice, which are closely related to rats ate them readily. The baits are apparently refused by rodents, other than rats and mice, although a quantity of approximately the same dose as for rats injected directly into the stomach of a woodchuck killed the animal.

Cases are recorded in other countries of animals killed by squill, and there is record of one death of a human being from taking sirup of white squill as a medicine. Not all the attending circumstances are known, however, and in several cases of death alleged to have been caused by squill that were carefully investigated, the animals were found to have died from entirely different causes. There may be here noted the instance of a young woman taking as an emetic $1\frac{1}{2}$ teaspoons of a commercial red-squill powder, which was apparently about three-fourths of a grain per pound of body weight; depression, dizziness, nightmare, vomiting, and diarrhea resulted, but no pain, and full recovery came on the third day. One of the authors of this leaflet swallowed 15 grains of a toxic red-squill powder with no apparent harm, and later took 40 grains, which caused nausea and vomiting within 15 minutes, but no other effect.

It is concluded, therefore, that red-squill powder when mixed with food in the concentration recommended for rat control is not likely to cause serious harm to farm animals in good health. It is possible that the irritant may cause death under certain conditions; so far as possible, therefore, red-squill baits for rats should be kept out of reach of other animals.

EXPERIENCE has shown that objectionable odors resulting from decaying rat carcasses are less likely to occur if a slow-acting poison is used. Red squill is slow acting and gives the sick rats opportunity to retire to burrows in the ground, into sewers, or

Deodorants to other situations from which odors do not ordinarily penetrate to structures above. Records show that odors develop on only about 1 out of every 20 premises treated with red-squill rat baits, and few persons are unwilling to run the risk of an occasional odor when trying to rid their homes of rats. Should rats die where the carcasses can not be removed without undue expense, the offensive odor arising from the putrefying bodies can be somewhat abated by the use of certain chemicals. Compounds of formaldehyde, chlorine, and cresol are sold at drug stores as deodorants. Deodorant solutions such as sodium hypochlorite may be sprayed around the room, added to the water used in scrubbing, or used to saturate cloths hung in the rooms where the odor is prevalent. A lead-nitrate solution also has been recommended for this purpose. Whether these deodorant compounds actually combine with and neutralize or destroy the offensive odors of putrefaction, or merely disguise them, is not definitely known, but practical tests have demonstrated their helpfulness. Odors from dead rats seldom last longer than four to six days.

